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Survey of the Freshwater Mussel Fauna of the Powell River, Virginia

Lisa T. Wolcott[1] and Richard J. Neves
Virginia Cooperative Fish and Wildlife Research Unit[2]
National Biological Survey
Department of Fisheries and Wildlife Sciences
Virginia Polytechnic Institute & State University
Blacksburg, Virginia 24061

INTRODUCTION

The Powell River, in Lee and Wise counties, Virginia supported an abundant and diverse freshwater mussel fauna. Ortmann (1918) reported 41 species of freshwater mussels from the Powell River, but predicted the eventual decline of mussel populations from human impacts. As judged by recent reports of declines in density and species richness of mussels (Ahlstedt & Brown, 1979; Neves et al., 1980; Dennis, 1981; Ahlstedt, 1986; Jenkinson & Ahlstedt, 1988), his prophecy has been realized. Environmental degradation from coal mining has been implicated as a cause of mussel declines in the last two decades (Ahlstedt & Brown, 1979; Neves et al., 1980; Dennis, 1981; Ahlstedt, 1986; Jenkinson & Ahlstedt, 1988). In the early 1980's, the full length of the Powell River was reported to run black with coal fines on occasion (Ahlstedt, 1986). In 1983 a die-off of mussels was reported from Powell River Mile (PRM) 67.0 to 143.0 and continued at least until 1986 (Ahlstedt & Jenkinson, 1987).

Ortmann (1918) collected mussels as far upstream as Big Stone Gap (PRM 178.2), but subsequent surveys reported sites above PRM 140 to be heavily impacted by coal and silt deposition, and no mussels were found above PRM 165 (Ahlstedt & Brown, 1979; Neves et al., 1980; Dennis, 1981; Ahlstedt, 1986). Ahlstedt (1986) listed 36 mussel species in the Powell River, including 15 species endemic to the Cumberland Plateau Region. Seven endangered species (federal list) reside in the Powell River: dromedary pearlymussel (*Dromus dromas*), shiny pigtoe (*Fusconaia cor*), fine-rayed pigtoe (*F. cuneolus*), cracking pearlymussel (*Hemistena lata*), birdwing pearlymussel (*Lemiox rimosus*), Cumberland monkeyface (*Quadrula intermedia*), and Appalachian monkeyface (*Q. sparsa*).

Jenkinson & Ahlstedt (1988) documented a decline in overall mean abundance of freshwater mussels at selected sites in the Powell River over the past decade: 7.25 mussels/m^2 in 1979, 4.87 mussels/m^2 in 1983, and 2.41 mussels/m^2 in 1988. They found that many species declined significantly between 1979 and 1983, perhaps reflecting the mussel die-off that occurred in 1983 (Ahlstedt & Jenkinson, 1987). Because of discrepancies in reports of mussel diversity from previous surveys and the suspected but undocumented declines in recruitment within populations, we conducted a mussel survey to reassess the diversity, range, and relative abundance of species in the Powell River, Lee County, Virginia.

MATERIALS AND METHODS

Study Area

The Powell River flows southwesterly from near Norton, Virginia, through the Ridge and Valley Province of the Appalachian Mountains into Tennessee, where it joins the Clinch River in Norris Reservoir. Study sites in the Powell River, Virginia, were selected according to suitability of habitat for mussels, similarity among sites (such as riffles, runs, and type of substratum), and accessibility (Figure 1). Most sites were selected from a list of locations previously surveyed so that comparisons could be made (Ahlstedt & Brown, 1979; Neves et al., 1980; Dennis, 1981; Ahlstedt, 1986; Jenkinson & Ahlstedt, 1988).

Qualitative Sampling

Qualitative sampling was conducted to assess distribution and relative abundance of uncommon mussel species not likely to be collected in quadrat samples. Fifteen sites were surveyed using a combination of waterscopes, snorkeling, and wading (Table 1). Surveying times ranged from 0.5 to 3 h, depending on the amount of suitable habitat at each site. All mussels observed during

[1]Present address: Route 1, Lake-O-Woods, Bruceton Mills, WV 26525.
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this time were collected, identified, measured, and replaced. Numbers of the state-protected spiny riversnail (*Io fluvialis*) also were recorded.

Quantitative Sampling

Quantitative surveys were conducted at nine of the 15 sites on the Powell River, identified by Powell River Mile: 117.3, 120.4, 123.0, 128.4, 144.6, 146.8, 153.4, 163.4, and 165.7 (Table 1). One 0.5-m^2 quadrat was taken for every 100 m^2 of suitable mussel habitat, which included optimal and marginal areas. A minimum of 10 quadrats and a maximum of 20 quadrats were taken at each site. Quadrat samples were obtained using a 0.5-m^2 metal frame, and samples were allocated among riffles and runs according to area. Quadrat points were located randomly. The substratum was searched to about 15 cm in depth with the aid of a mask and snorkel. All live mussels contained in the 0.5-m^2 area were removed, identified, and measured for length (maximum anterior to posterior distance). Mussels were replaced near their original location in the siphoning position. Numbers were converted to densities per square meter at each site. Densities of the exotic Asian clam (*Corbicula fluminea* [Müller]) and the protected spiny riversnail also were recorded to determine the abundance of these species. Common and scientific names of mollusks follow Turgeon et al. (1988); authors of the scientific names are given in Table 2.

Mean densities among sites were compared by Kruskal-Wallis tests. Differences in mean lengths of the pheasantshell (*Actinonaias pectorosa*) were compared among sites and with previously collected data using ANOVA procedures.

RESULTS

Species Composition and Distribution

Quantitative and qualitative mussel sampling in 1988 and 1989 yielded 28 mussel species, including nine endangered species (five on federal list and four on state list; Table 2). The Tennessee pigtoe (*Fusconaia barnesiana*) and Tennessee clubshell (*Pleurobema oviforme*) are difficult to distinguish solely from external characteristics; therefore, these specimens were grouped together as one taxon. Endangered mussel species were found at several sites (Table 3), but not above Poteet Ford (PRM 144.6). The spiny riversnail also was found at most sites but was absent above PRM 163.4. No live mussels or relic shells were found above PRM 167.4. The sites with highest diversity on the Powell River in Virginia were located farthest downstream, and there was an obvious increase in the number of species of mussels from upstream to downstream (Figure 1).

Two of the most diverse sites in the downstream portion of the river are at Fletcher Ford (PRM 117.3) and Snodgrass Ford (PRM 123.0). Sampling at Fletcher Ford recorded 19 mussel species. Snodgrass Ford, not previously documented as a mussel bed, supported a diverse and abundant fauna of 22 mussel species.

Mussel Densities in Quadrat Samples

Mussel densities declined progressively upstream, and mussels were very rare above PRM 163.4 (Table 4). Mussel abundances were too low upstream of PRM 163.4 to be quantified by quadrat sampling; however, mussels were collected by qualitative sampling. Comparison of mussel densities by Kruskal-Wallis analysis showed significant differences among sites (P=.0001), and multiple comparisons were made using Wilcoxon two-sample tests

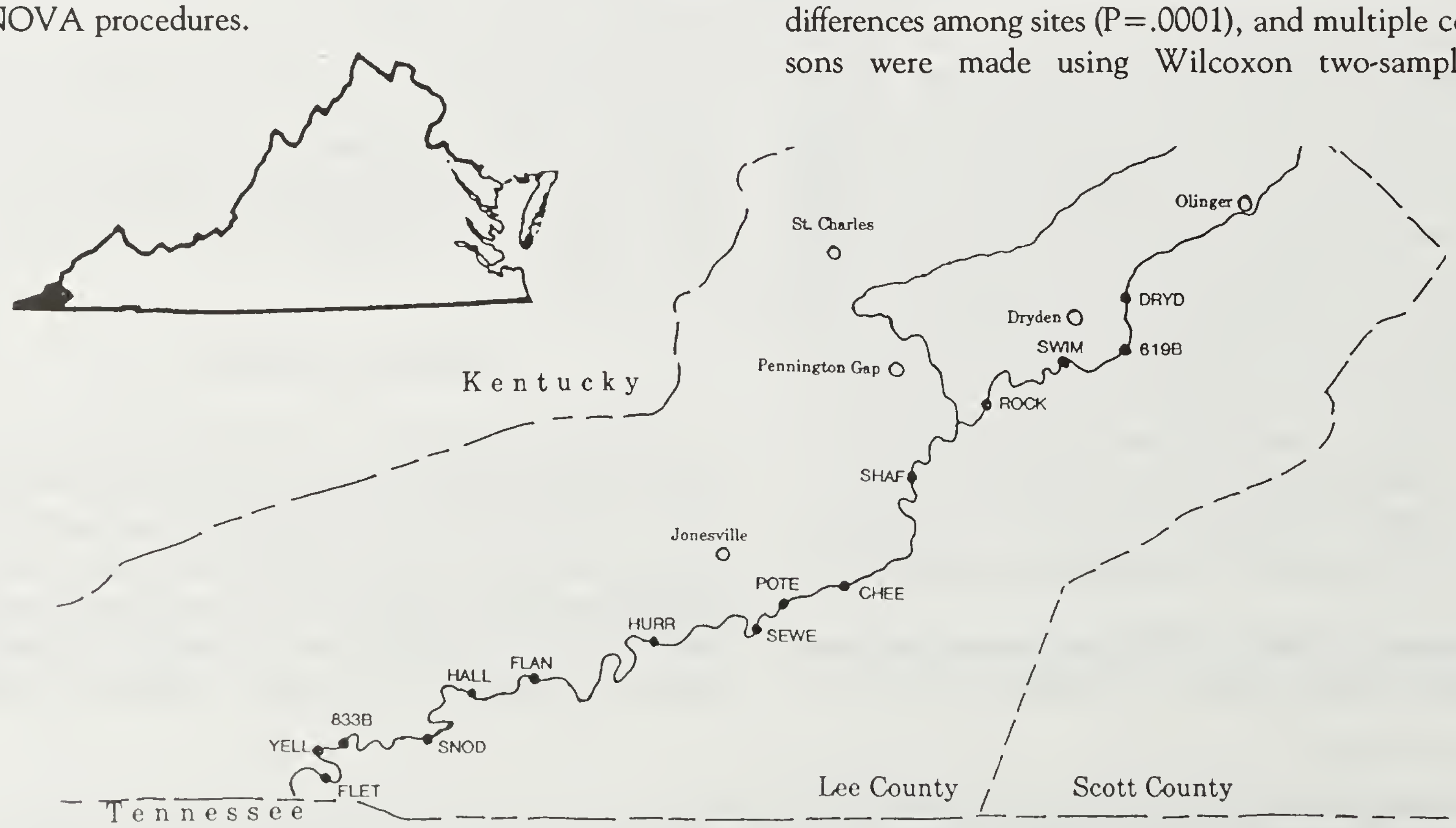

Figure 1. Sample sites on the Powell River, Lee County, Virginia.

Table 1. Sites sampled for mussels in the Powell River, Virginia, 1988-89.

Site (abbreviation)	River Mile	Location
Fletcher Ford (FLET)	117.3	Rte. 678 off Rte. 661; private access, locked gate.
Yellow Creek (YELL)	119.3	Rte. 661, above swinging bridge; downstream of Yellow Creek confluence.
Rte. 833 Bridge (833B)	120.4	Rte. 833 bridge off Rte. 661.
Snodgrass Ford (SNOD)	123.0	Rte. 667 off Rte. 679; approx. 0.5 mile downstream of swinging bridge.
Hall Ford (HALL)	128.4	Gravel road off Rte. 662; under swinging bridge.
Flanary Bridge (FLAN)	130.6	Downstream of Rte. 758 bridge.
Hurricane Bridge (HURR)	138.3	Downstream of Rte. 654 bridge.
Sewell Bridge (SEWE)	143.5	Rte. 70 bridge.
Poteet Ford (POTE)	144.6	Gravel road off Rte. 783; downstream of swinging bridge.
Cheekspring Ford (CHEE)	146.8	Rte. 783; under swinging bridge.
Shafer Ford (SHAF)	153.4	Rte. 640; side of island.
Rock Island (ROCK)	158.3	Gravel road off Rte. 642.
Swimming Hole (SWIM)	163.4	Gravel road off Rte. 642; downstream of swinging bridge.
Rte. 619 Bridge (619B)	165.5	Downstream of Rte. 619 bridge.
Dryden (DRYD)	167.4	Gravel road at Rte. 58 bridge; at island upstream of bridge.

(Table 5). Snodgrass Ford had a significantly higher mussel density (24/m^2) than all other sites. Densities of mussels at Fletcher Ford and the Route 833 bridge were not significantly different from each other but were greater than at all other sites. Densities of the spiny riversnail were significantly different among sites ($P=.0001$), with the highest numbers occurring at Snodgrass Ford and Fletcher Ford (Table 5). Densities of Asian clams also were significantly different among sites ($P=.0001$), with the highest numbers occurring at Hall Ford, Snodgrass Ford, Fletcher Ford, and at the Route 833 bridge (Table 5).

Qualitative Samples

The number of mussel species collected was greater in qualitative surveys than quantitative surveys (Table 6). Generally, most of the common species were collected in quadrat samples, while rarer species were found during qualitative sampling. The highest number of species was collected at Fletcher Ford. The pheasantshell (*A. pectorosa*) and mucket (*A. ligamentina*) were the most common mussel species at sampled sites. The number of mussels and species collected per unit of effort declined progressively upstream, except at some midstream sites (Table 6). Results of collection per unit effort data concur with quadrat samples on longitudinal trends in abundance; namely, mussel abundance decreased in an upstream direction.

Size Class Differences Among Sites

Lengths of mussels were used to represent age

structure of populations at sample sites. Mean lengths of *A. pectorosa* were compared by ANOVA among three sites with sufficient sample sizes, and there were significant differences (P=0.0001) among locations (Table 7). The mean length (86.7 mm) of *A. pectorosa* was lowest at the Route 833 bridge, indicating better recruitment and mid-age adults at this site. Snodgrass Ford had the highest mean length (106.9 mm), which implies reduced recruitment. Size class distributions of *A. pectorosa* show similar trends (Table 8); however, the lack of young mussels is evident at all sites. Although a large sample (n=139) of *A. pectorosa* was collected at Snodgrass Ford, no individuals less than 60 mm in length were observed. Age estimates from length data indicate that few individuals are less than 7 years old, suggesting low recruitment over the last decade.

Shell lengths of *A. pectorosa* collected at Fletcher Ford during quadrat surveys in 1988 were compared with those taken in 1978 (Neves et al., 1980). A t-test indicated no significant difference in average lengths of *A. pectorosa* between the 2 years (P=0.5388). A comparison of median length classes between these years, however, indicated an obvious decline in the number of smaller mussels at this site. The collection of only one specimen in the first seven median size classes in 1988 implies poor recruitment over the last decade (Table 9).

Table 2. Mussel species collected in the Powell River, Virginia, 1988 and 1989.

Scientific name	Common name
Actinonaias ligamentina (Lamarck)	mucket
Actinonaias pectorosa (Conrad)	pheasantshell
Amblema plicata plicata (Conrad)	three-ridge
Cyclonaias tuberculata (Rafinesque)	purple wartyback
Dromus dromas (Lea)[1]	dromedary pearlymussel
Elliptio dilatata (Rafinesque)	spike
Epioblasma brevidens (Lea)[2]	cumberlandian combshell
Epioblasma capsaeformis (Lea)[2]	oyster mussel
Epioblasma triquetra (Rafinesque)[2]	snuffbox
Fusconaia barnesiana (Lea)	Tennessee pigtoe
Fusconaia cor (Conrad)[1]	shiny pigtoe
Fusconaia subrotunda (Lea)	long-solid
Lampsilis fasciola (Rafinesque)	wavy-rayed lampmussel
Lampsilis ovata (Say)	pocketbook
Lasmigona costata (Rafinesque)	fluted-shell
Lemiox rimosus (Rafinesque)	birdwing pearlymussel
Ligumia recta (Lamarck)[2]	black sandshell
Medionidus conradicus (Lea)	Cumberland moccasinshell
Plethobasus cyphyus (Rafinesque)[2]	sheepnose
Pleurobema oviforme (Conrad)	Tennessee clubshell
Potamilus alatus (Rafinesque)	pink heelsplitter
Ptychobranchus fasciolaris (Rafinesque)	kidneyshell
Ptychobranchus subtentum (Say)	fluted kidneyshell
Quadrula cylindrica strigillata (Wright)	rough rabbitsfoot
Quadrula intermedia (Conrad)[1]	Cumberland monkeyface
Quadrula sparsa (Lea)[1]	Appalachian monkeyface
Villosa iris (Lea)	rainbow
Villosa vanuxemensis vanuxemensis (Lea)	mountain creekshell

[1]Federal endangered species
[2] State endangered species

Table 3. Locations of mussel species collected in the Powell River, Virginia, 1988 and 1989.

Species Site	FLET	YELL	833B	SNOD	HALL	FLAN	HURR	SEWE	POTE	CHEE	SHAF	ROCK	SWIM	619B	DRYD
River mile	117.3	119.3	120.4	123.0	128.4	130.6	138.3	143.5	144.6	146.8	153.4	158.3	163.4	165.5	167.4
Actinonaias ligamentina	X	X	X	X	X	X	X	X	X	X	X	.	.	.	.
Actinonaias pectorosa	X	X	X	X	X	X	X	X	X	X	X	X	X	.	X
Amblema plicata plicata	.	.	X	X	X	X	.	X	X	.	.	.	.	.	.
Cyclonaias tuberculata	X	X	X	X	X	.	.	X	X	.	.	.	.	.	.
Dromus dromas	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.
Elliptio dilatata	X	X	X	X	X	.	.	X	X	X	X	X	.	X	.
Epioblasma brevidens	X	.	X	X	X	.	.	X	.	.	.	.	.	.	.
Epioblasma capsaeformis	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Epioblasma triquetra	X	.	.	X	X	X	.	.	.	.	.	.	.	.	.
Fusconaia/Pleurobema	X	.	X	X	X	.	.	.	X	X	.	.	.	.	.
Fusconaia cor	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
Fusconaia subrotunda	X	X	X	X	X	X	X	X	X	X	X	X	.	.	X
Lampsilis fasciola	X	X	X	X	X	.	X	X	X	X	X	X	X	.	X
Lampsilis ovata	.	X	X	X	.	X	X	X	X	.	X	.	.	.	.
Lasmigona costata	X	.	X	X	X	X	X	X	X	X	X	.	.	.	.
Lemiox rimosus	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.
Ligumia recta	X	.	X	X	.	.	.	.	.	X	.	.	.	.	.
Medionidus conradicus	X	X	X	X	X	.	.	X	.	.	.	.	.	X	.
Plethobasus cyphyus	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.
Potamilus alatus	X	.	.	X	.	X	X	X	X	X	X	.	.	.	.
Ptychobranchus fasciolaris	X	X	X	X	.	.	.	X	X	X	X	X	.	.	X
Ptychobranchus subtentum	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
Quadrula cylindrica strigillata	.	.	X	.	.	X	.	X	X	.	X	X	.	.	.
Quadrula intermedia	X	X	X	X	X	.	.	X	X	.	.	.	.	.	.
Quadrula sparsa	X	X	.	.	.	.	.	.	X	.	.	.	.	.	.
Villosa iris	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X
Villosa v. vanuxemensis	.	.	.	.	.	.	.	.	.	X	X	X	X	X	.
Total species	19	12	18	22	14	9	7	15	16	11	11	7	3	3	5
Federal endangered spp.	4	3	2	3	1	.	.	1	3	.	.	.	.	.	.
State endangered spp.	3	.	2	3	2	1	.	1	.	.	.	.	.	.	.

DISCUSSION

Species Composition and Distribution

Species composition and distributional differences are apparent when survey results from this study are compared with survey data of the last 15 years (Ahlstedt & Brown, 1979; Neves et al., 1980; Dennis, 1981; Ahlstedt, 1986; Jenkinson & Ahlstedt, 1988). More mussel species were found at sites upstream of Flanary Bridge (PRM 130.6) than was reported by earlier surveys (Table 10). Because unusually low and clear water conditions in 1989 facilitated sampling, discrepancies among studies in species densities and richness at upstream sites are presumably due to ineffective sampling in previous surveys and not to recovery of mussel populations. Generally, species diversity has decreased at lower sites (below PRM 130.6) since earlier surveys. Loss of species richness is probably due to extirpations of some species at lower sites and is not an artifact of sampling method or effort.

Declines in mussel diversity and distribution in the Powell River are obvious when compared with mussel surveys of the early 1900s (Ortmann, 1918). Particularly noticeable is the current absence of mussels upstream of

Table 4. Number of mollusks per square meter in quadrat samples from the Powell River, 1988.

Species:	Site:	FLET	833B	SNOD	HALL	POTE	CHEE	SHAF	SWIM	619B
	River mile:	117.3	120.4	123.0	128.4	144.6	146.8	153.4	163.4	165.7
Mussels										
Actinonaias ligamentina		0.7	0.5	5.0	0.2	-	-	-	-	-
Actinonaias pectorosa		3.7	3.0	13.9	0.6	0.1	0.8	0.2	-	-
Cyclonaias tuberculata		0.1	-	-	-	-	-	-	-	-
Dromus dromas[1]		-	-	0.1	-	-	-	-	-	-
Elliptio dilatata		0.4	0.6	2.2	-	0.1	-	-	-	-
Epioblasma brevidens[2]		0.3	0.1	-	-	-	-	-	-	-
Fusconaia subrotunda		0.6	0.3	1.0	-	0.5	-	-	-	-
Lampsilis fasciola		0.1	-	-	-	-	-	0.2	-	-
Lampsilis ovata		-	-	0.1	-	-	-	-	-	-
Lemiox rimosus[1]		-	-	-	-	0.1	-	-	-	-
Ligumia recta[2]		-	-	0.1	-	-	-	-	-	-
Medionidus conradicus		0.5	0.6	1.4	-	-	-	-	-	-
Plethobasus cyphyus[2]		0.1	-	-	-	-	-	-	-	-
Quadrula intermedia[1]		-	-	0.2	-	-	-	-	-	-
Villosa v. vanuxemensis		-	-	-	-	-	-	-	0.2	-
Mean density (No./m^2)		6.5	5.1	24.0	0.8	0.8	0.8	0.4	0.2	-
Other Mollusks										
Corbicula fluminea		201.2	134.2	267.7	266.8	43.8	71.4	100.0	71.4	46.4
Io fluvialis		3.1	2.0	5.0	1.6	0.9	-	0.2	-	-
No. of Quadrats		20	20	20	10	20	10	10	10	10

[1]Federal endangered species
[2]State-endangered species

Table 5. Comparison of mean densities of mollusks among sites along the Powell River, as determined by quadrat sampling in 1988.

Mussels			Spiny Riversnail			Asian Clam		
Site	Mean	SE	Site	Mean	SE	Site	Mean	SE
SNOD	24.0a[1]	1.63	SNOD	5.0a	0.35	HALL	266.8a	19.14
FLET	6.5b	0.50	FLET	3.1ab	0.42	SNOD	267.7a	23.38
833B	5.1b	0.54	833B	2.0bc	0.33	FLET	201.2ab	22.13
HALL	0.8c	0.22	HALL	1.6bc	0.25	833B	134.2bc	13.26
CHEE	0.8c	0.22	POTE	0.9bc	0.17	SHAF	100.0bc	10.39
POTE	0.8c	0.18	SHAF	0.2cd	0.10	CHEE	71.4cd	10.39
SHAF	0.4c	0.13	CHEE	0.0d	0.00	SWIM	71.4cd	7.53
SWIM	0.2c	0.10	619B	0.0d	0.00	619B	46.4d	4.15
619B	0.0c	0.00	SWIM	0.0d	0.00	POTE	43.4d	3.92

[1]Means with the same letter are not significantly different ($p \geq 0.05$) according to Wilcoxon 2-sample tests.

Dryden (PRM 167.4). Ortmann (1918) collected mussels at least up to PRM 177.8 at Big Stone Gap. Mussels have not been collected upstream of PRM 167.4, at least as far back as 1973 (Dennis, 1981). Unfortunately, no records are available before that time to determine when mussels declined or disappeared from the upstream reaches of the Powell River, although effects from mining and industrialization have been ongoing for the last 50 years (Dennis, 1981). Mussels are thought to have been eliminated from the Big Stone Gap area because of acid mine drainage that occurred prior to environmental regulations (Wollitz, 1985).

At least nine mussel species have been extirpated from the Powell River, Virginia, since Ortmann's (1918) report: elktoe (*Alasmidonta marginata* [Say]), slippershell mussel (*A. viridis* [Rafinesque]), elephant-ear (*Elliptio crassidens* [Lamarck]), acornshell (*Epioblasma haysiana* [Lea]), Tennessee heelsplitter (*Lasmigona holstonia* [Lea]), little-wing pearlymussel (*Pegias fabula* [Lea]), squawfoot (*Strophitus undulatus* [Say]), purple lilliput (*Toxolasma lividus* [Rafinesque]), and purple bean (*Villosa perpurpurea* [Lea]). Several of these species were headwater forms and probably were affected by upstream pollution; others were present only downstream and were eliminated by Norris Dam and the impoundment of the Clinch and Powell rivers (Ahlstedt & Brown, 1979; Dennis, 1981). Several species may have extended their range upstream in the last 70 years. The mucket (*A. ligamentina*) is common at most sampled sites in Virginia, but was not collected by Ortmann (1918) above the Tennessee border. Similarly, some species reported in recent surveys were not documented by Ortmann (1918) in the Powell River, Tennessee or Virginia, although most of them are rare and probably were missed in his early surveys. However, the purple wartyback (*C. tuberculata*) is now fairly common and may be a recent invader (Ahlstedt & Brown, 1979).

Sharp declines in mussel densities in the Powell River are obvious when compared with previous collection records. During 1978, Neves et al. (1980) provided a mean density estimate of 24.2 mussels/m^2 at Fletcher Ford. Quadrat surveys by Jenkinson & Ahlstedt (1988) at Fletcher Ford estimated densities of 11.1 mussels/m^2 in 1979, 10.3 mussels/m^2 in 1983, and 5.5 mussels/m^2 in 1988. Our survey estimated an abundance of 6.5 mussels/ m^2 in 1988. While densities often vary among similar sites in a river, periodic sampling of the same site should provide a precise estimate of mussel abundance (Dennis, 1984). As judged by these density estimates, a substantial decline in mussel abundance has occurred at this site, probably due to lack of recruitment and mortality of adult mussels.

The distribution of the spiny riversnail also has declined. Historically, *Io fluvialis* was collected above Olinger, Virginia (PRM 172.0), by Adams (1915). The spiny riversnail was collected up to PRM 163.4 in our survey; however, densities decreased markedly upstream of PRM 128.4. In 1979, spiny riversnails were collected up to PRM 156.8, with maximum densities of 5.7/m^2 (Tennessee Valley Authority, 1979). The highest density of 5.0/m^2 in our survey was recorded at Snodgrass Ford (PRM 123.0). As judged by survey results, the upstream range of *Io fluvialis* has decreased roughly 15.5 km since 1915.

Length Frequency Distributions

Unfortunately, few historical data on length frequencies are available to compare changes in mussel sizes

or age class structure over time. Only Neves et al. (1980) recorded mussel lengths during their survey. Statistical analyses and size class structure confirm that the number of smaller (younger) mussels has decreased in the last 10 years at Fletcher Ford. The 1980 quadrat survey indicates that younger mussels can be sampled by quantitiative sampling methods. However, the absence of individuals in six of the smallest length classes in 1988 indicates that the lack of recruitment has been a long-term event and is not related solely to variable recruitment among years. Length frequency histograms of common species such as *A. ligamentina*, *F. subrotunda*, and *E. dilatata* confirmed the lack of young age classes for all species. Recruitment of young mussels at this site is not occurring, and mussel populations are in decline for as yet unknown reasons.

Length frequency distributions also were used to identify poor recruitment at other sites. Mean lengths of *A. pectorosa*, the most abundant mussel in the Powell River, were smallest at the Route 833 bridge. This site was the only place where smaller (juvenile) mussels were collected. At Snodgrass Ford, no evidence of recruitment was found, and old-age individuals made up the entire assemblage. Mussel densities at Snodgrass Ford were similar to those recorded at Fletcher Ford in 1978 (Neves et al., 1980). Snodgrass Ford should be monitored periodically to determine whether reproduction and recruitment are occurring at this diverse site. The presence of endangered species such as the dromedary (*D. dromas*) and Appalachian monkeyface (*Q. sparsa*) at this location warrants further evaluation.

Mussel Declines

Because mussels are long-lived animals, effects of environmental change may not be evident for many years. Improvements in water quality occurred in the Powell River when discharges came under federal and state regulation; however, the mussel fauna may still be suffering from the effects of degradation that occurred many years ago.

Our conclusion from length frequency analyses and survey results is that, at present, almost no recruitment of

Table 6. Collection of mollusks per unit of sampling effort in the Powell River, 1988.

Site	River Mile	Number of mussels	Number of species	Mussels /hour	Number of spiny riversnails	Snails /hour
FLET	117.3	333	16	111.0	124	41.3
YELL	119.3	220	11	73.3	13	4.3
833B	120.4	103	15	34.3	27	13.5
SNOD	123.0	554	14	184.7	156	52.0
HALL	128.4	92	9	30.7	23	7.7
FLAN	130.6	24	9	12	6	3.0
HURR	138.3	63	7	25.2	0	0
SEWE	143.5	143	15	47.7	6	2.0
POTE	144.6	148	14	49.3	27	10.8
CHEE	146.8	75	10	25.0	4	1.3
SHAF	153.3	11	4	4.4	2	1.0
ROCK	158.3	20	7	6.7	25	8.3
SWIM	163.4	2	1	1.6	1	0.8
619B	165.5	3	3	2.0	0	0
DRYD	167.4	0	0	0	0	0

Table 7. Differences in mean lengths of pheasantshells (*Actinonaias pectorosa*) among sites, as determined by ANOVA of quadrat and qualitative surveys, 1988.

Quadrat Surveys		Qualitative Surveys	
833B	86.7a[1]	833B	101.8a
FLET	100.1b	YELL	104.6ab
SNOD	106.9c	POTE	107.8bc
		FLET	109.7c
		HALL	109.7c
		SNOD	114.4d
		CHEE	114.0d
		SEWE	116.8d
		HURR	119.3d

[1]Means with the same letter are not significantly different ($p \geq 0.05$) according to Fisher's protected least-significant-difference procedure (LSD).

mussels is occurring at most sampled sites in the Powell River. Possible reasons for this lack of recruitment include impaired or lack of reproduction, mortality of juveniles, loss of host fishes, or a combination of these factors. A comparison of data from fish surveys in 1988 (Alan Temple, unpublished data) with those of Tennessee Valley Authority (1970), Masnik (1974), and Neves et al. (1980) showed no major reductions or changes in fish species over time. Therefore, the diversity and availability of host fish species probably has not declined significantly in the Powell River. However, the absolute and relative abundances of these fish species over time has not been determined.

Mussel declines in Atlantic drainage rivers have been attributed to the development of dense populations of the Asian clam (Clarke, 1988). This exotic species first appeared in the Powell River in 1979 (Ahlstedt, 1986) and was considered common by 1983. It is now widespread in the river and may be competing for food and space with juvenile native mussels. Research is needed to investigate the potentially negative interactions between these bivalve taxa.

Contaminants

Water quality in the Powell River generally exceeds standards established by the Virginia Water Control Board (1985). However, there are only two ambient water quality stations on the Powell River, and samples are taken only monthly at best. More frequent or high flow sampling would be more appropriate because many types of pollution are episodic events, occurring during storms or incidents of permit violations. Pollution from agriculture, logging, domestic sewage, coal mining and other industries has increased since Ortmann (1918) collected mollusks in the Powell River. Although several sources of pollution exist, perturbations originating from coal mining, and abandoned mine lands are potential point and non-point source problems affecting the upper Powell River drainage.

Conservation and protection of the diverse mussel fauna in the Powell River will depend on the identification and correction of environmental problems detrimental to mollusk survival and reproduction. Cooperative monitoring and research by state regulatory agencies and

Table 8. Median size class distribution and estimated age of pheasantshells, as determined by quadrat and qualitative surveys, 1988.

	Median size class (mm) (Estimate of age)														
SITE	5 (1)	15 (2)	25 (3)	35 (4)	45 (5)	55 (6)	65 (7)	75 (8)	85 (9-10)	95 (11-12)	105	115	125	135	145
Quantitative samples															
FLET	-	-	1	-	-	-	-	3	7	5	7	10	3	1	-
833B	2	1	-	-	-	-	-	3	5	11	6	2	-	-	-
SNOD	-	-	-	-	-	-	1	5	10	27	37	42	20	2	-
HALL	-	-	1	-	-	-	-	-	-	-	3	-	-	-	-
CHEE	-	-	-	-	-	-	-	-	-	-	1	2	1	-	-
SHAF	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Qualitative samples															
FLET	-	-	-	-	-	-	-	1	17	25	39	80	30	4	1
YELL	-	-	-	-	-	-	2	1	13	22	40	44	3	-	-
833B	-	-	-	-	-	-	-	1	8	6	15	9	2	-	-
SNOD	-	-	-	-	-	-	-	2	1	17	40	84	58	4	2
HALL	-	-	-	-	-	-	-	-	1	7	5	13	12	-	-
FLAN	-	-	-	-	-	-	-	-	-	1	1	3	1	-	-
HURR	-	-	-	-	-	-	-	-	-	-	-	7	3	2	-
SEWE	-	-	-	-	-	-	-	-	-	2	10	15	11	4	-
POTE	-	-	-	-	-	-	-	-	-	2	23	15	1	-	-
CHEE	-	-	-	-	-	-	-	-	1	1	9	19	9	1	-
SHAF	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-
ROCK	-	-	-	-	-	-	-	-	-	-	3	1	-	-	-

federal agencies such as the Office of Surface Mining, Environmental Protection Agency, and U.S. Fish and Wildlife Service is essential to achieve recovery of mussels in the Powell River watershed.

SUMMARY

A survey of the freshwater mussel fauna of the Powell River, Virginia, was conducted in 1988 and 1989 to assess diversity and population trends during the last half century. Mussels were collected as far upstream as Powell River Mile (PRM) 167.4 near Dryden, Virginia. Endangered species were collected up to PRM 144.6 at Jonesville, Virginia. Sites with the greatest mussel diversity were downstream, and there was an obvious decline in abundance and diversity progressing upstream. The highest density occurred at Snodgrass Ford (PRM 123.0), with 24 mussels/m^2. Live mussels were rare above Pennington Gap (PRM 158.3), whereas historic records of mussels were as far upstream as Bigstone Gap (PRM 178.2). A decline in density of mussels in the Powell River has occurred in the past 25 years. Statistical comparisons of quadrat data and length frequency distributions of the pheasantshell (*Actinonaias pectorosa*) indicate an absence of smaller mussels at most sites. There is little if any recruitment of young mussels to declining populations. Effluents and siltation from coal mining, abandoned mine lands, and wastewater treatment plants are suspected of contributing to the decline of mussels.

Table 9. Median size class distribution of pheasantshells, as determined by quadrat surveys at Fletcher Ford in 1978 and 1988.

	Median size class (mm)														
Year	5	15	25	35	45	55	65	75	85	95	105	115	125	135	145
1978	-	2	4	1	5	3	-	7	8	12	16	17	17	6	1
1988	-	-	1	-	-	-	-	3	7	5	7	10	3	1	-

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Table 10. Species diversity reported in mussel surveys conducted at selected sites in the Powell River, Virginia.

Site (PRM)		Survey*						
		A	B	C	D	E	F	G
FLET (117.3)		28	12	17	27	15	10	19
YELL (117.9)	-	-	26	10	0	-	3	
833B (120.4)		24	21	18	11	-	-	18
SNOD (123.0)	-	-	-	-	-	-	22	
HALL (128.5)	-	-	5	18	-	-	14	
FLAN (130.6)	4	8	13	-	6	5	9	
HURR (138.3)	-	1	6	-	-	-	7	
SEWE (143.5)	-	-	2	-	-	-	15	
POTE (144.6)		9	12	5	-	-	-	16
CHEE (146.8)	0	-	-	-	-	-	11	
TRAS (153.4)	-	-	2	-	-	-	11	
ROCK (158.3)	-	-	0	-	-	-	7	
SWIM (163.4)	-	-	1	-	-	-	3	
619B (165.7)		2	1	-	-	-	-	3
DRYD (167.4)	1	1	4	-	-	-	5	

*A = 1973-1978 (Dennis 1981)
B = 1975-1978 (Ahlstedt and Brown 1979)
C = 1979 (Ahlstedt 1986)
E = 1983 (Jenkinson and Ahlstedt 1988)
F = 1988 (Jenkinson and Ahlstedt 1988)
G = 1988-1989 (present study)